

Guidelines & Remedial measures to prevent damages to Approaches of Submersible & High Level Submersible bridges proposed under PMGSY / MMGSY schemes.

**Government of Maharashtra
Rural Development Department**

Government Circular No.: PMGSY-2022/C.R.200/Works-2

Bandhkam Bhavan, 25 Marzban Road, Fort,
Mumbai-400 001

Date: 17th October, 2022

Introduction :-

Maharashtra Rural Development Agency under Rural Development Department, Government of Maharashtra is executing ambitious schemes like Pradhan Mantri Gram Sadak Yojana & Mukhyamantri Gram Sadak Yojana for improvements of rural roads in state. In which construction of roads and minor / major bridges is undertaken on Village Roads & other District roads, taken under these schemes.

The bridges dealt with, are generally High level submersible or submersible type clearing ordinary flood levels. The Approaches for bridges are to be designed with submersible treatments and upstream & downstream aprons are to be provided to protect beds in case of bridges with raft foundations. However due to non-execution of Approaches with requisite treatments and standard specifications and non-provision of bed protections in case of bridges with raft foundations or due to unexpected sudden rise in flood levels, the approaches of submersible bridges gets damaged and river beds gets eroded, resulting in stoppage of traffic and damage to foundations. In view of this committee headed by Superintending Engineer, PMGSY, Nagpur was set up vide Govt. Order No. GSY-2022/CR-200/Bandhkam-2, Mantralay, Dt.04/08/2022 to study & suggest provisions to be made in bridge estimates & to suggest remedial measures to prevent damages to

approaches of submersible Bridges and erosion of river beds near foundations & damages to foundations of bridges. Various IRC codes and guidelines provides for provisions to be made in design and constructions of submersible bridges and approaches. The issue of making these guidelines available in concise form was under in considerations. Hence based on report and recommendations of committee, the detailed guidelines for preparations of DPR for submersible bridge and approaches is being issued as below.

Government Circular:-

1.0 Definitions

1.1 High Level Submersible Bridges:- When RTL of the bridge is fixed with reference to OFL and standard vertical clearance as such structure serves as high level bridge during OFL but gets submerged under higher flood with maximum 6 interruption of 6 to 12 hours per year then the bridge is called as high level submersible bridge.

1.2 Low Level Submersible Bridge:- When soffit of deck slab of bridge is fixed just above OFL so as to insure that the interruptions caused to traffic remain within permissible limit as mentioned in 1.1 above, is called as low level submersible bridge.

1.3 Causeways :-

A Causeway is a paved submersible structure with or without openings (vents) which allows flood to pass through and / or over it.

1.4 Flush causeway :-

The causeway which is also called paved dip or road dam, the top level of road is kept same as that of bed level of the channel is called as flush causeway. It is suitable where the crossing remain dry for most of part of year i.e. the stream is not perennial. Flush causeways are not suitable for crossing the streams with steep

bed slopes causing high velocity even in low floods. The causeway covers the full width of the channel. Refer Fig (1)

1.5 Vented Causeways :-

A Causeway provided with vents to permit normal flow of the stream to pass under the causeway is known as vented causeway. Vented causeways are classified as low vented causeways and high vented causeways.

1.5.1 Low vented causeway :-

Low vented causeways are provided to cross quasi-perennial streams having sandy beds in areas with annual rainfall less than 1000 mm and where the carriageway of a flush causeway would be liable to get slushy due to post monsoon flow in the stream. The height is generally less than 1.20 m above the bed. In exceptional cases, the height may be 1.50 m above the bed level. Small size of vents in the form of hume pipes, short span slab / RCC Box Cells are provided in the width of stream. The sill level of vents is kept about 150 mm – 300 mm below the average bed level of the stream. Refer fig. (2)

1.5.2 High vented causeway :-

High vented causeway is provided when a road crosses a stream having one or more of the following characteristics:

- i. Sizeable catchment area with annual rainfall more than 1000 mm,
- ii. Depth of post monsoon flow is more than 900 mm
- iii. Flow is perennial but not large

The height of the causeways above the bed shall be kept between 1.5 m to 3.0 m and larger size of vents comprising of hume pipes or simply supported / continuous R.C.C. slab superstructure over a series of short masonry piers or series of arches or boxes with individual spans less than 3.00 m are adopted. Refer fig (3)

2.0 Criteria for avoiding / selection of submersible structures

Submersible structures may not be considered for adoption in the following situations

- a) Roads of economic importance, roads linking important towns or industrial areas or areas with population more than 10,000 where alternative all weather route with reasonable length of detour is not available.
- b) On roads which are likely to be upgraded or included, from future traffic considerations, in the National Highway network.
- c) If the length of a high level bridge at such crossings would be less than 30 m except where construction of high level structure is not economically viable.
- d) Maximum mean velocity of stream during floods is more than 6 m/sec.
- e) If the cost of submersible bridge with its approaches is estimated to be more than approximately 70% of the cost of high level bridge with its approaches, near about the same site.
- f) If the height of embankment for submersible portion of approaches is more than 2 m.
- g) Where there are faults in the river bed.
- h) If after completion of the submersible structures, the number of interruptions in a year caused to traffic and duration of the interruptions are likely to exceed the suggested values given in IRC.

3.00 Requirements of various components / parameters in design of submersible bridges and their protection works.

3.1 Approach Road of submersible bridge / causeway :-

The approaches on either side of a submersible bridges should have a minimum straight & level length of 15 m and should be suitably increased, where necessary, to provide for the minimum sight distance for a vehicular speed of 35 km/h. Horizontal curves in immediate approach roads for a length of about 100 m on either side of a submersible structure or causeways should be generally avoided.

3.2 Design Speed :-

From consideration of safety of road users, lower design speed than that recommended in IRC: 73 should be adopted for the immediate approaches to a submersible bridge or causeway. The informative boards installed on approaches should indicate permissible speed of 35 km/h in case of plain and rolling terrain and 20 km/h in case of mountainous and steep terrain irrespective of any higher speed adopted in the design of the road.

3.3 Camber / Crossfall :-

The camber/crossfall on straight sections of immediate approaches and on submersible structure should be unidirectional towards the downstream and as recommended in following Table, depending on type of surface of pavement.

Sr.No.	Surface Type	Unidirectional Cross fall (%)
1	For all categories of roads High Type bituminous surfacing or cement concrete	2.0
2	Thin bituminous surfacing for approaches	2.5
3	Brick/stone set pavement	3.0

Shoulders of approach roads likely to be submerged during floods should be paved to same cross fall towards downstream as for pavement.

3.4 Gradients:-

As a general rule, values of ruling gradients specified in IRC:73 should be adopted. However, in case of immediate approaches to submersible structure,

carrying substantial slow traffic, flatter gradients than ruling values should be preferred. Nevertheless, gradients in immediate approaches unless, otherwise permitted by user authority, should not exceed 5% (1 in 20) Limiting gradient, irrespective of nature of terrain.

3.5 Sourcer shape/ trapezoidal longitudinal section of Bridge & Approaches:-

3.5.1 Need of trapezoidal L-Section:-

Afflux is more in case of submersible bridge than that of high level bridge. Further high afflux increases velocity which causes high moments on pier foundations. In order that excessive afflux and thereby hypercritical velocity are not created, the deck level of submersible bridge should be kept low. The bed erosion and afflux are interlinked. Thus higher Afflux will create more velocity obstruction, leading to bed erosion and damage to approach. The percentage of obstructions to the flood discharge is maximum when the flood rises just up to the top level of the submersible bridge. This condition causes erosion of banks and subsequent outflanking. Therefore, deciding RTL is one of the critical conditions for the design of submersible bridge. Trapezoidal / Sourcer shaped longitudinal sections of bridge and approaches are considered as hydraulically efficient safest longitudinal section. Hence to minimize % obstruction and spread of floods, maximum flow (@ HFL) shall be allowed over the trapezoidal / saurcer shaped longitudinal section of bridge/causeway deck and approaches sloping towards bridge/causeways.

3.5.2- Design for trapezoidal L-Section and its provisions:-

This can be achieved by providing Trapezoidal / longitudinal shape of Saurcer Shaped Bridge with approaches. Thus RTL of the Submersible Bridge shall be judiciously decided so that flood discharge of OFL shall clearly pass through vents of bridge. In case of high floods excess discharge is allowed to flow over

trapezoidal L-section with permissible limit of time & occurrence of flood. The approaches upto HFL shall be designed as submersible approaches, So that there will not be failure during high floods. The trapezoidal L-Section shall be provided by providing gradient of 1:20 to 1:30 on both side approaches. Slope shall be started beyond 15 meters from approach slab of bridge with introduction of well designed vertical curves in approaches. Refer fig (4)

3.6 Formation of Trapezoidal L-Sections in Approaches in cutting and protective measures to be provided:-

The approach roads to Submersible Bridge should preferably be in cutting with the approach gradient not steeper than 1 in 20. The sloping portions of the approach should merge into level portion of the bridge in the arc of a properly designed vertical curves in order to eliminate bumping. It is preferable to have the approach in cutting as the embankments are liable to be washed away during floods. In cutting, however, there may be the problem of silting but the same can be appreciably reduced if the approaches are aligned at a slight angle to the centre line of the bridge so that the gradient falls in the direction of the river flow. The approaches in cutting would get submerged for a considerable period therefore these should be provided with safe side slopes considering the submerged condition. Further, deep cutting (say more than 4 m) should invariably be avoided. Wherever steep side slopes are provided for the approaches in cutting, it is experienced that, the slopes slip over the road pavement and it becomes a recurring problem to clear it, after every flood. The values of safe side slopes for the different types of soil under submerged condition are given in table below.

Type of Soil	Vertical	Horizontal
Soft Soil	1:	2 ½

Type of Soil	Vertical	Horizontal
B.C. Soil	1:	2
Soft Murum	1:	1 $\frac{1}{2}$
Hard Murum	1:	1

The sides of cutting of Approaches should be protected by stone pitching up to at least 1 m above the Affluxes HFL. This would avoid souring of sides of cutting & consequent silting of Approaches. (Refer Fig.5 & 6 for pitching)

Lined drains on either side along the side slopes should be provided. The lining may be either stone or brick or concrete. The Lined drains should meet the stream proper at least 10 m away from the edge of the main bridge junction as the flow of water in the drains would erode the banks for certain length in course of time. (Refer Fig.7 for drum alignment) In case of straight return walls, minimum 3 m long walls perpendicular to the return walls should be provided to avoid undermining of foundations of return wall or/and abutments. In case of submersible bridges founded on sandy beds, extraction of sand/soft material beyond apron and curtain wall should not be done as this may endanger the safety of the structure. Fig (7) for lined drains.

3.7 Pavement for submersible approaches :-

Length of approaches up to the spread of affluxed highest flood is subjected to repeated inundation and is always prone to outflanking. Therefore the roadway should be paved in a similar manner to that of the main Submersible Bridge i.e. full width bituminous treatment shall be provided in approaches. The paved approach roadway in cutting needs to be confined between anchor-walls. Refer Fig (8) & (9)

3.8 Construction methods and provisions to be made for submerging approaches in Embankment :-

When the submerged approaches are in embankments then the possibility failure of approaches is like approaches cutting D/s side outflanking, washout of embankments, surface erosion etc.

To prevent such failure following precautions needs to be taken, while constructing the approaches.

- i. Additional vents in form of pipes or box culverts shall be provided on both side approaches for quick draining / recession of flood water to downstream side. It helps in quick recession of flood waters of upstream side fields and minimize damages to crops standing in fields.
- ii. Material used for embankments construction shall have CBR value more than 5%
- iii. Layered compactions with maximum thickness of 150mm, at OMC shall be ascertained.
- iv. Side slopes shall be protected by providing stone pitching with pointing.
- v. Kerb stones at the edge of pavement of approach shall be provided to confine the pavement material.
- vi. The edge kerb stone facing flow at upstream & downstream shall be rounded so as to act as hydraulically efficient edge.
- vii. If it becomes necessary to provide the approaches in embankment then proper protection of approaches is to be done with stone pitching & toe wall. Also Full width of the roadway of approaches likely to be submerged should be paved. Refer fig (10) to (13) for cross-section of Approaches in Embankment for different Terrains & ground profiles.

4.0 Requirement of other Protection Work in submersible bridges:-

4.1 RCC stopper shall be provided on D/S of pier cap of submersible bridge.

4.2 Collapsible:- steel Pipe & Angle railing is recommended for submersible bridge.

4.3:- The floor protection should be properly designed as per the detailed guidelines contained in IRC : 89. The rigid flooring under the structure should extend for a distance of at least 3m on upstream side and 5m on downstream side of the structure. **(Refer Fig 14)**

However if splayed wing walls are provided, the flooring should extend up to the line connecting the end of the wing walls on either side of the structure. The top of the flooring should be kept 600mm below the lowest bed level to prevent the flooring from acting as a weir. It is essential that the work of bed protection is simultaneously completed along with the work of the foundations of structure to prevent any damage to the foundations. No stone weighing less than 40 kg should be used in apron. Where required size stones are not economically available Cement Concrete block (M-15 grade) or stones in wire crates or cement concrete blocks and stones in combination may be used in place of isolated stones of equivalent weight. Cement concrete blocks should however, be preferred wherever possible.

4.4 Bed Protection or Floor Protection for Shallow Foundations :-

In case of submersible structures, where adoption of shallow foundations becomes economical by restricting the scour, bed (floor) protection to the structures has to be provided. The bed / floor protection consists of the following components:

- Upstream and Downstream flexible apron with a slope of 1:8
- Upstream and Downstream cut-off wall. Cut-off Wall shall be at least 300 m below maximum scour level.

4.5 Bed protection or floor protection not required for deep foundations or open foundations in shallow rock strata –

wherever deep foundations like well & end bearing pile foundations resting in hard rock strata and hard non-erodible beds are existing, bed protection works are not required to be provided.

4.6:- Debris Arrester:-

During monsoon particularly during the first couple of rains a lot of debris is carried by floods. This debris gets obstructed by the piers and the superstructure. This causes damages to structure and obstruction to flow of water. The phenomenon is more pronounced in the case of bridges in forest areas when the floods carry a lot of trees and branches. This situation can be quite dangerous for smaller spans. Generally the banks get out flanged if the structure is strong enough to withstand water current forces. It is, therefore, desirable to resort to spans of minimum 8m or so. This will allow a lot of debris to pass through the bridge. If the spans are smaller in comparison to the size of debris, debris arresters should be provided about 50m on up stream of the bridge site so that there is free flow of floodwater through the bridge. The different types of Debris Arresters/guiders to be used are shown in photos. The debris Arresters may be circular steel pipe 50m on u/s bridge or sloping wall at pier location to arrest debris.Refer Photo's(1)&(2)

5.0 Maintenance of existing bridges, causeways approaches and strengthening of existing beds and submersible approaches wherever required-

5.1 If failure approaches is found due to blocking of flow by debris and tree branches then debris arrester shall be provided at 50 m towards the U/S of bridge.

5.2 Timely clearing at arrester side shall be ensured before onset of monsoon.

5.3 wherever waterways are blocked due to debris or silting, then desilting and debris removal shall be carried out and waterways shall be cleared in all C.D. works & bridges before onset of every monsoon.

5.4 If failure of high bank approach is found then provision of pipes in approach should be thought in order to minimize water pressure and for quick draining of stranded water from upstream fields of submersible approaches.

5.5 Adequate Toe wall /Breast wall with pitching shall be constructed towards D/S of approach as per the stranded designs & drawings enclosed herewith.

5.6 If possible D/S nallah shall be trained in the shape of approaches so that there will be easy flow of flood water.

5.7 Pre monsoon & post monsoon inspection of bridges and approaches shall be done and required repairs, strengthening shall be carried before onset of monsoon.

These are the guidelines are based on prevailing IRC & SP Codes mentioned above. However the amendments to related IRC codes shall be deemed to be applicable to these guidelines.

This Government circular of Maharashtra Government is available at the website www.maharashtra.gov.in. Reference no. for this is 202210171507576420. This Circular has been signed digitally.

By order and in the name of the Governor of Maharashtra.

(**Vijaykumar Choudhari**)
Desk Officer, Government of Maharashtra.

DA- As above

Annexure- 1) Figure No. 1 to 14.

2) Photo 1 to 4.

Copy forwarded to:

1. Chief Engineer (PMGSY), MRRDA, Pune.
2. Chief Executive Officer, Zilla Parishad (All)
3. Superintending Engineers (PMGSY), MRRDA (ALL)
4. Executive Engineers, (PMGSY), MRRDA (ALL)

5. Executive Engineers, Zilla Parishad, (Construction Division) (ALL)
6. Under Secretary (Bandhakam-1), Rural Development Department, Bandhakam Bhavan, Fort, Mumbai 400 001.
7. Select file, Bandhakam-2, Rural Development Department, Bandhakam Bhavan, Fort, Mumbai 400 001.

**Annexures to Government Circular No. PMGSY-2022/C.R.200/Works-2,
Rural Development Department, date 17th October, 2022.**

Figure No.1

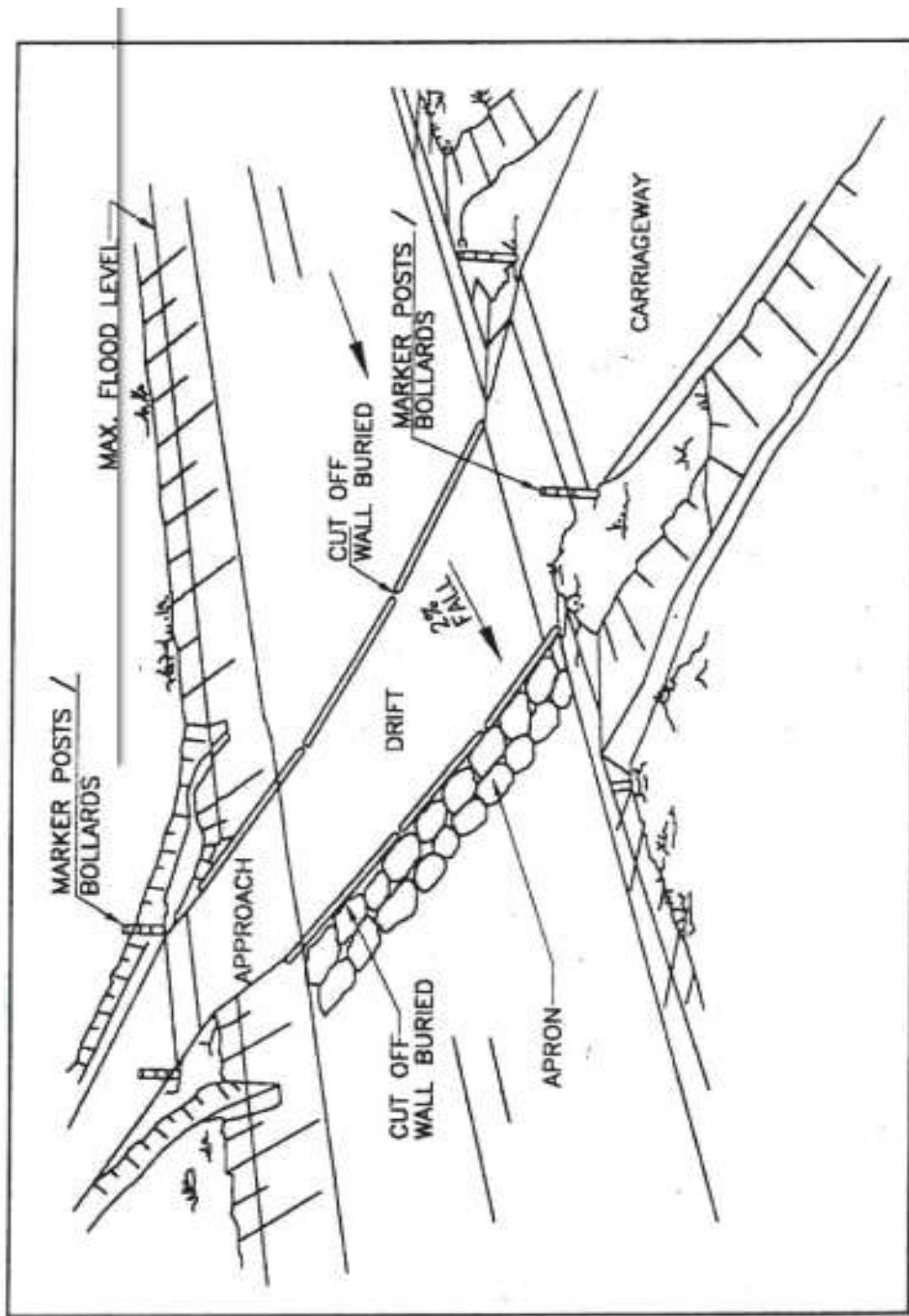


Fig. 3.2. Typical Features of Paved dip/Flush Causeway

Figure No. 2

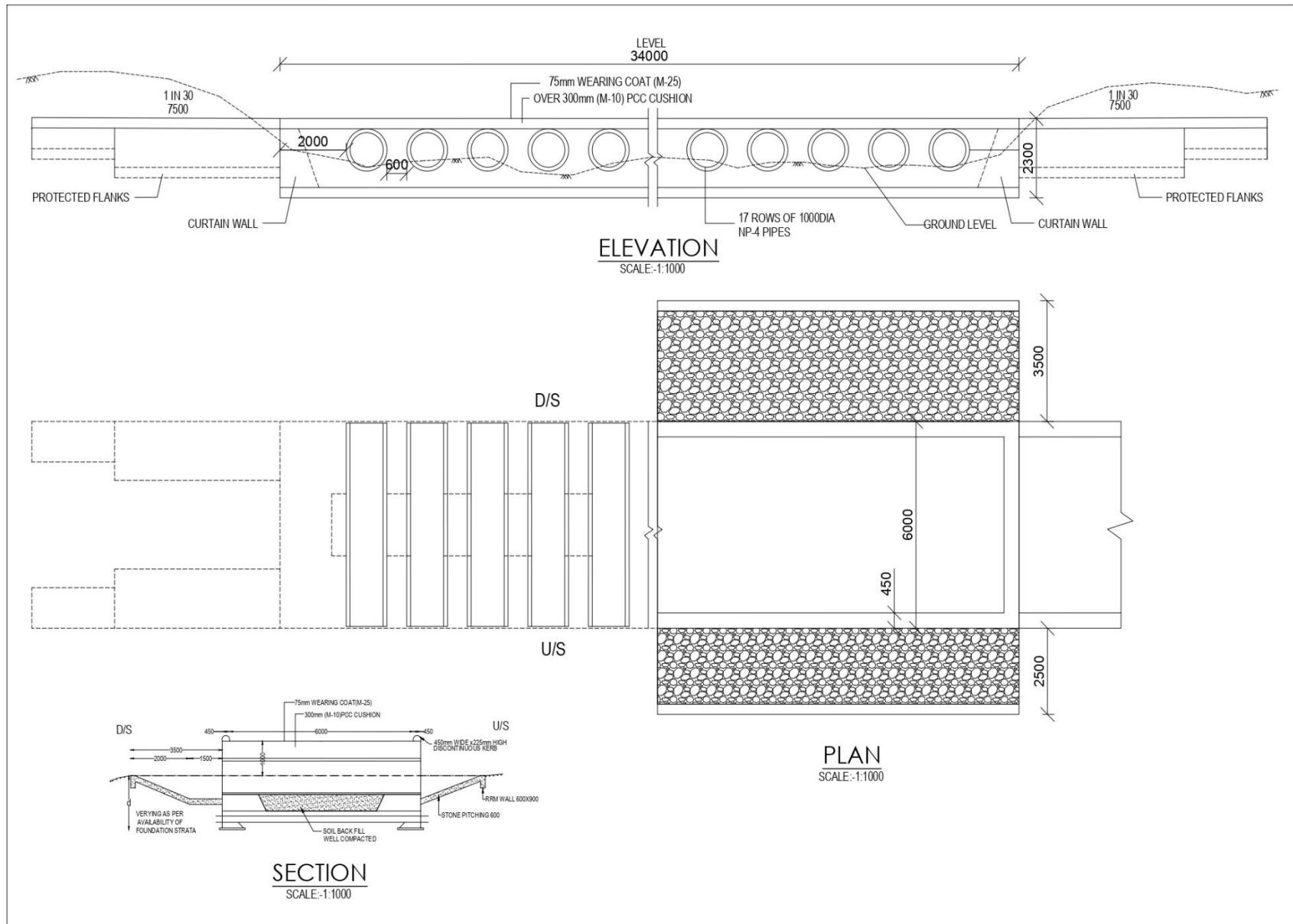


Fig. 7.8 Details of vented causeway (Appendix 7.2)

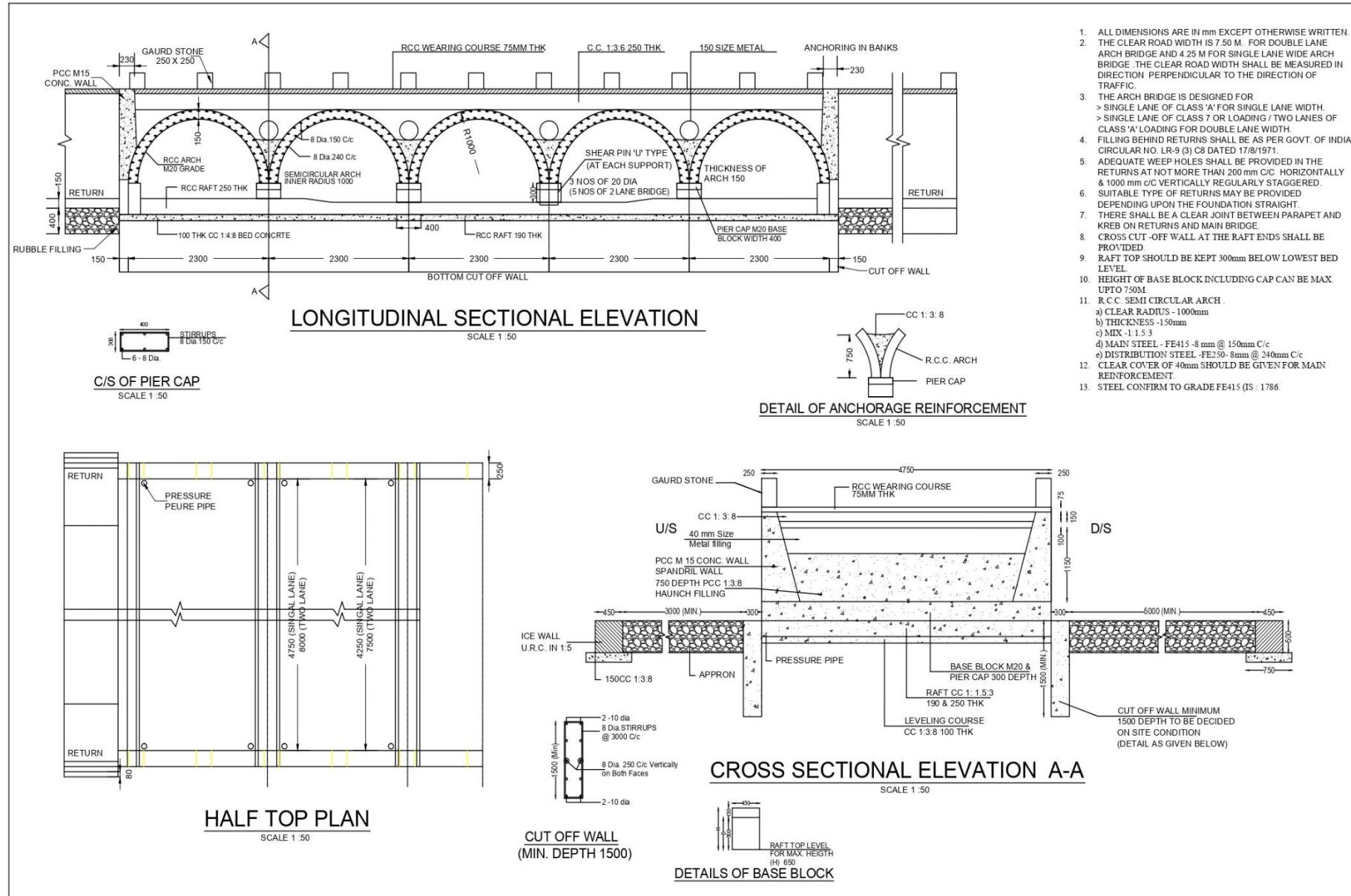


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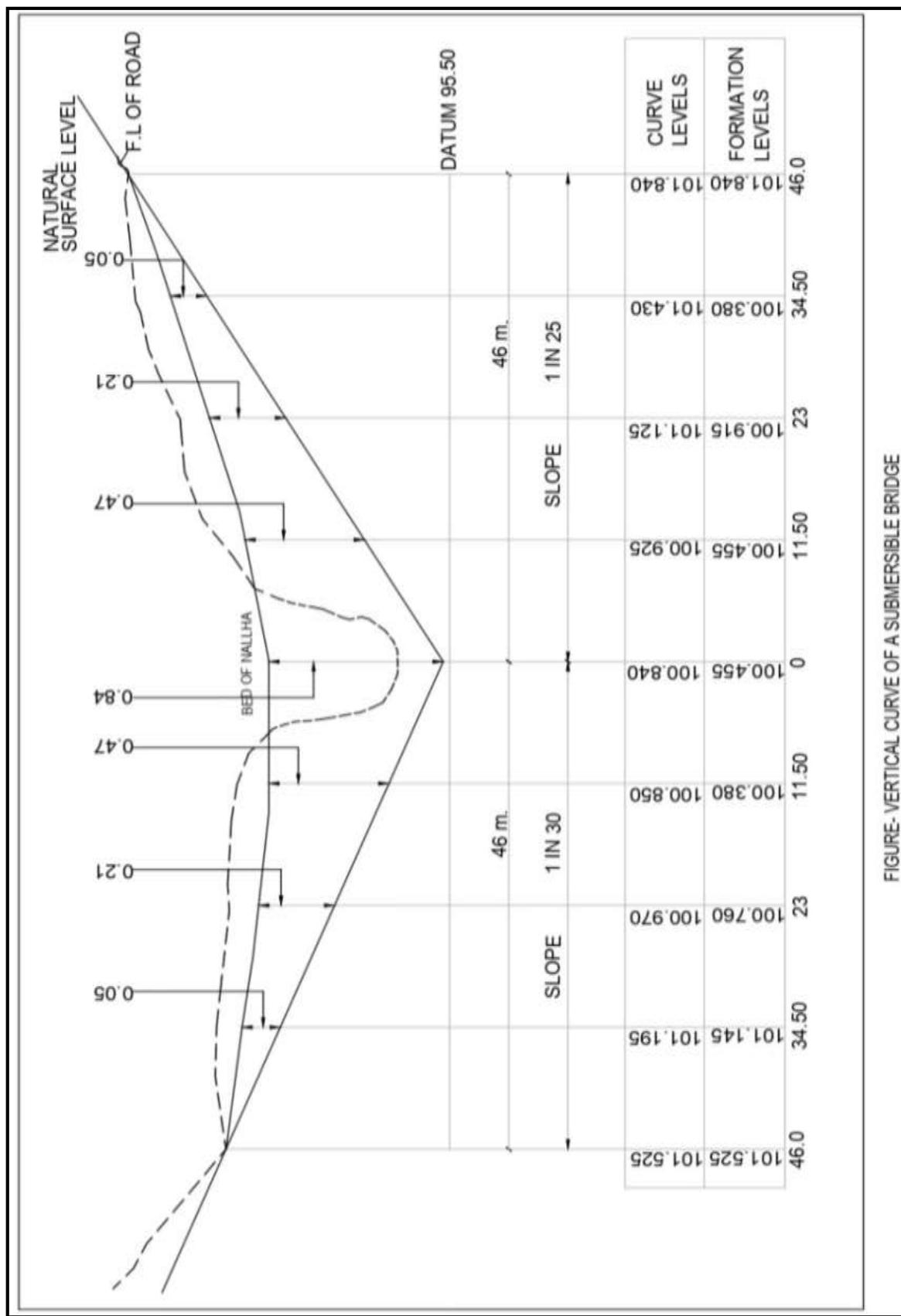


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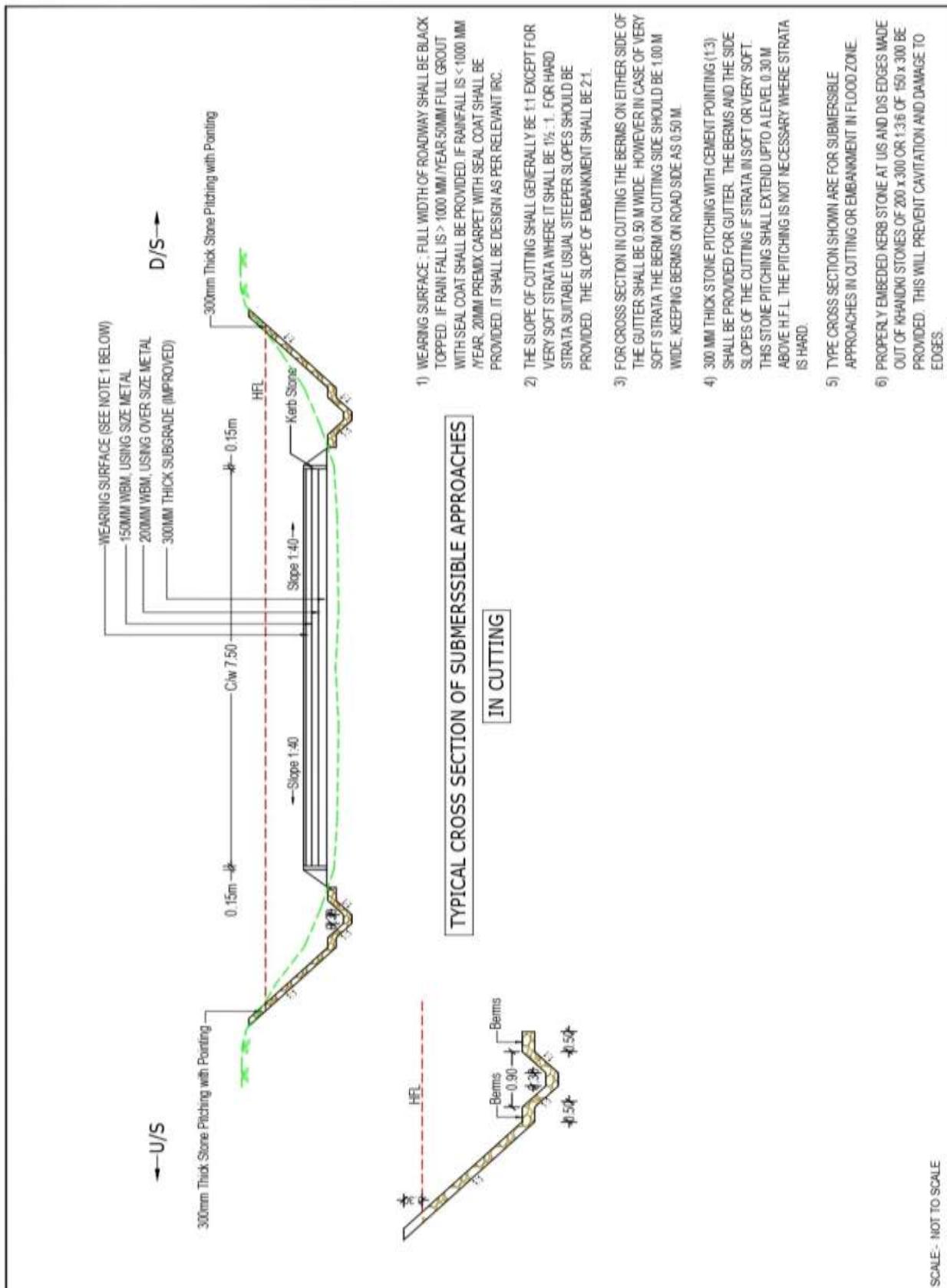


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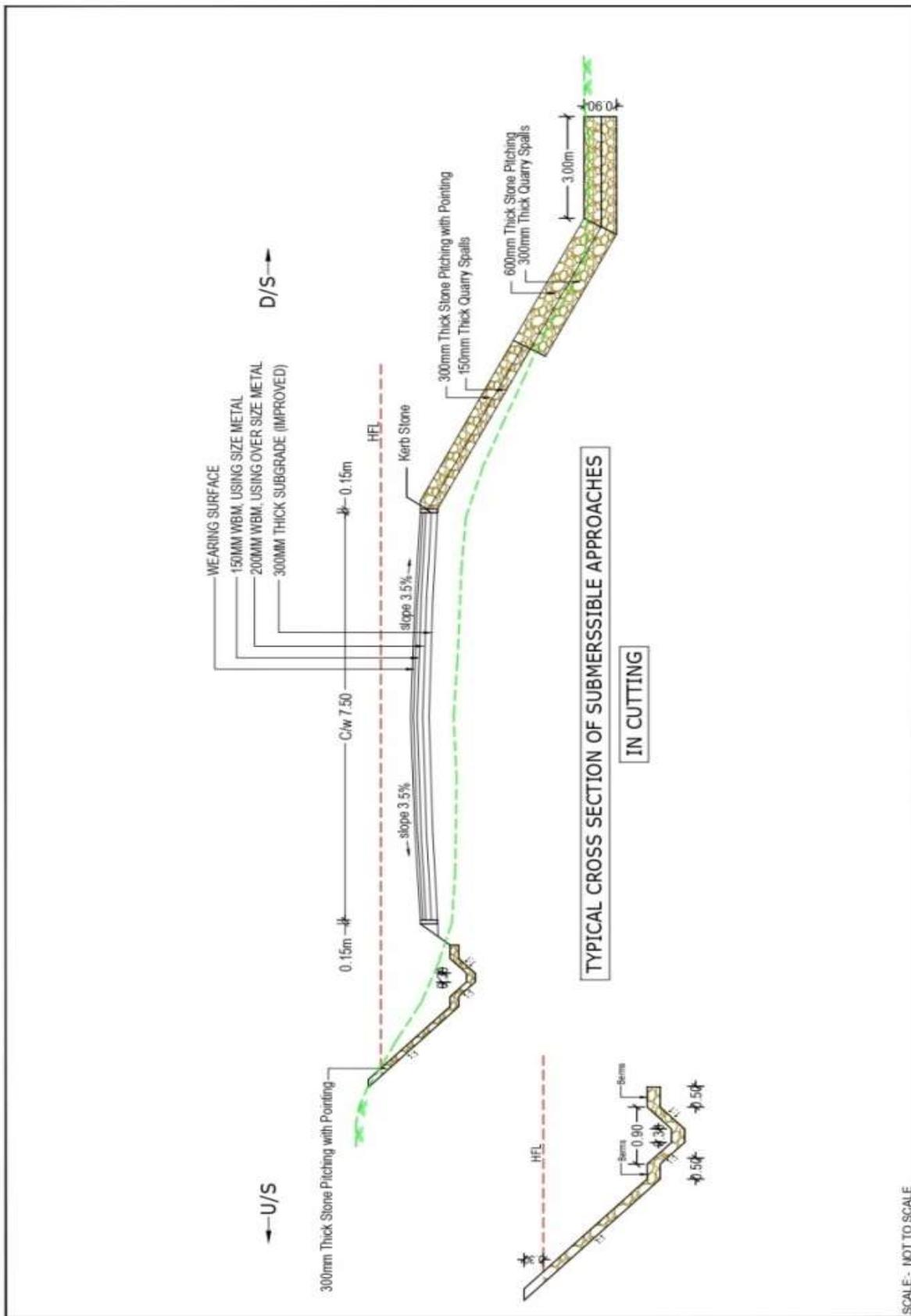


Figure No.7

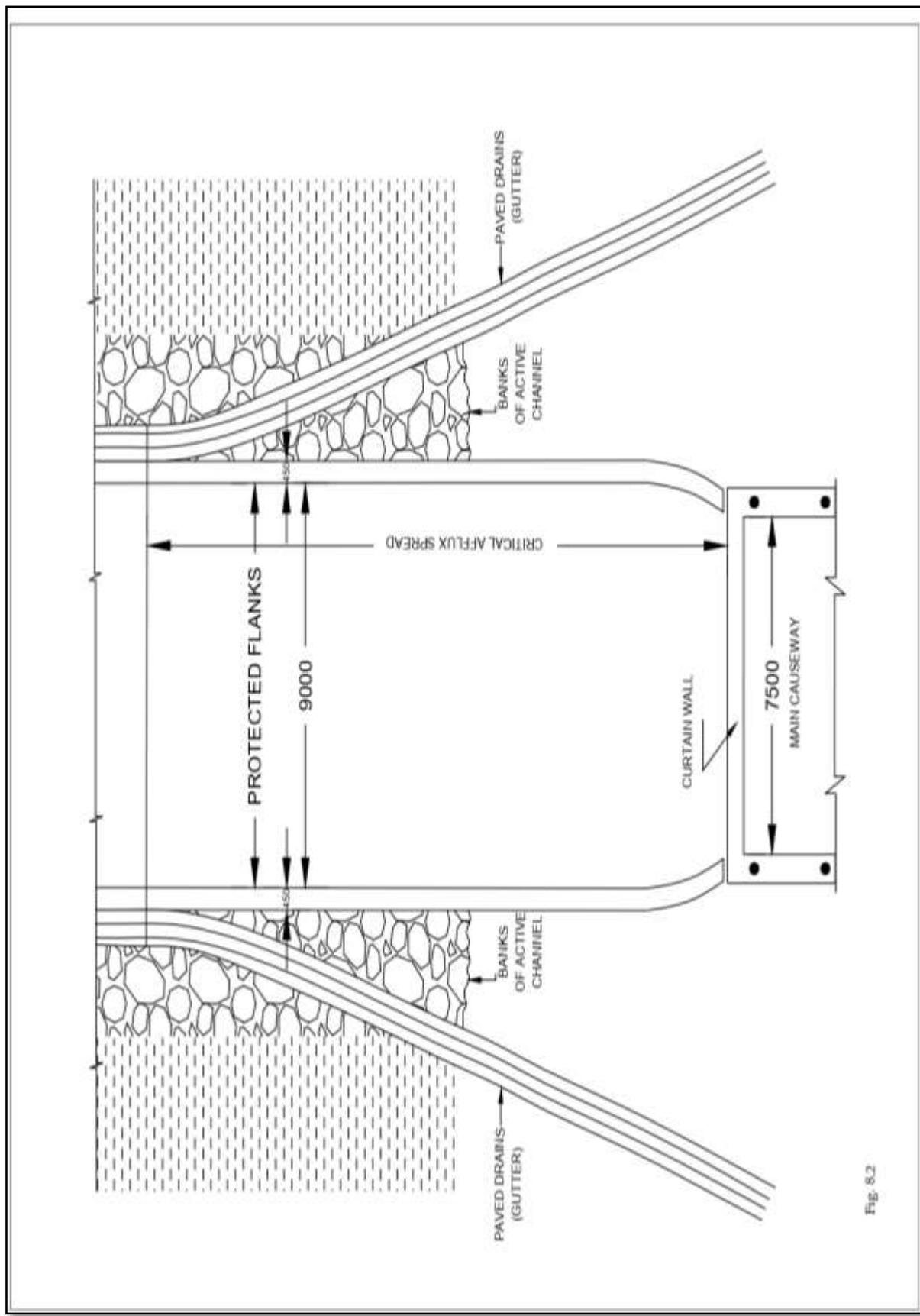
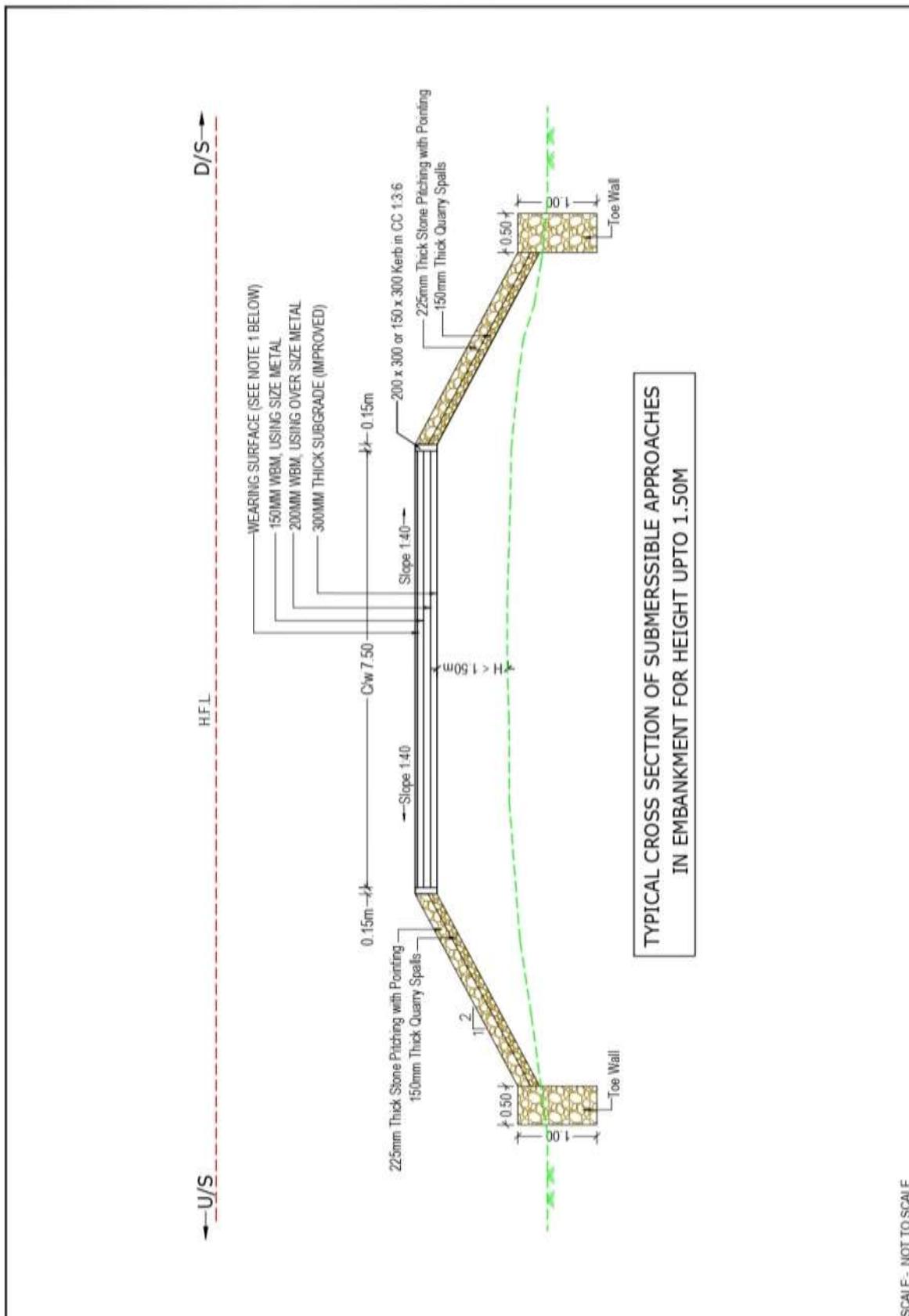


Fig. 8.2

Figure No.8



SCALE- NOT TO SCALE

Figure No.9

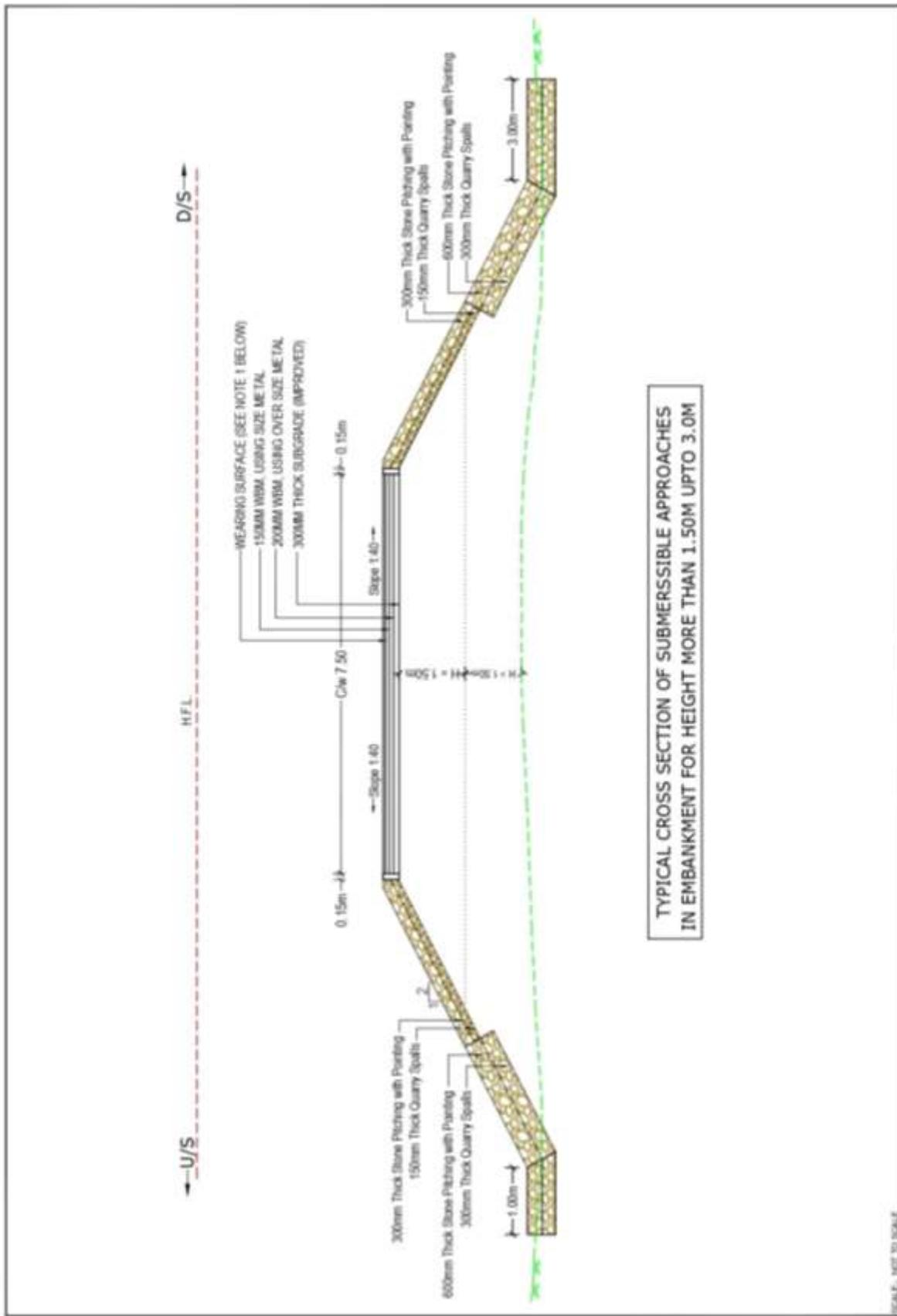


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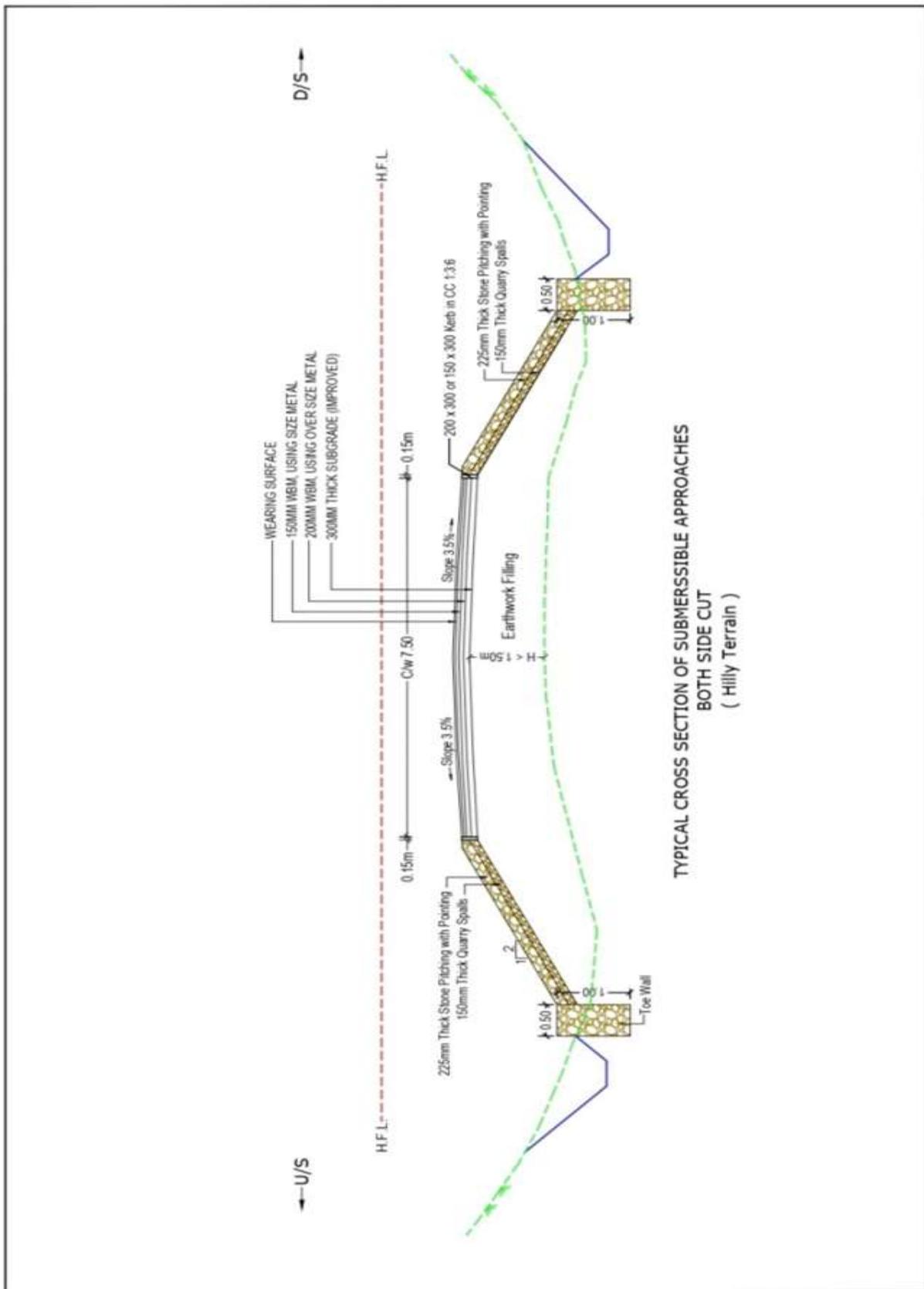
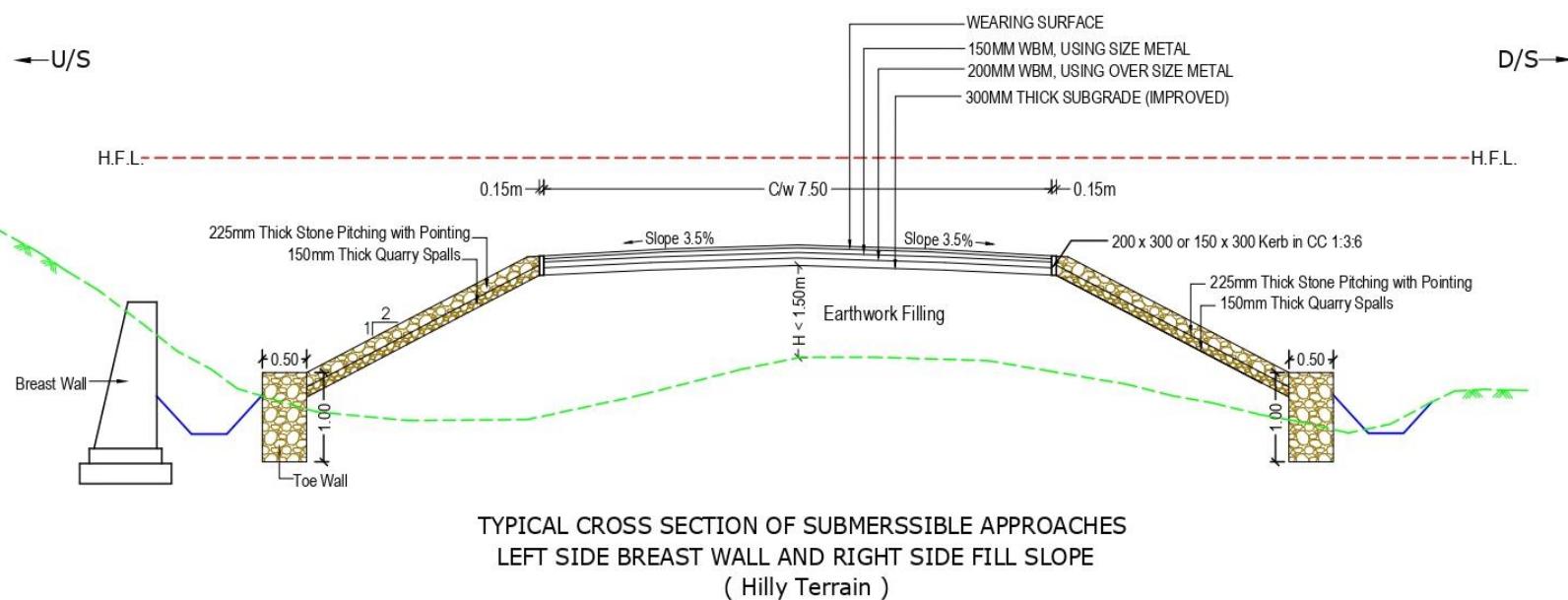


Figure No. 11



SCALE:- NOT TO SCALE

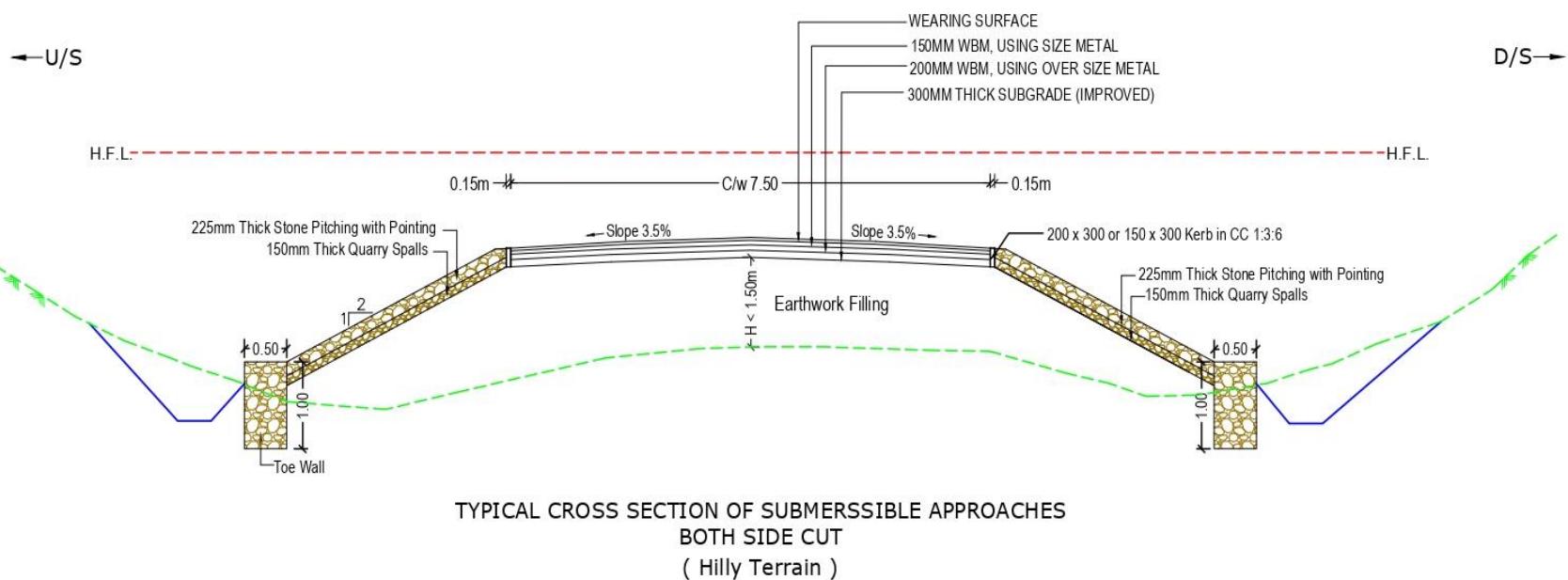


Figure No. 13

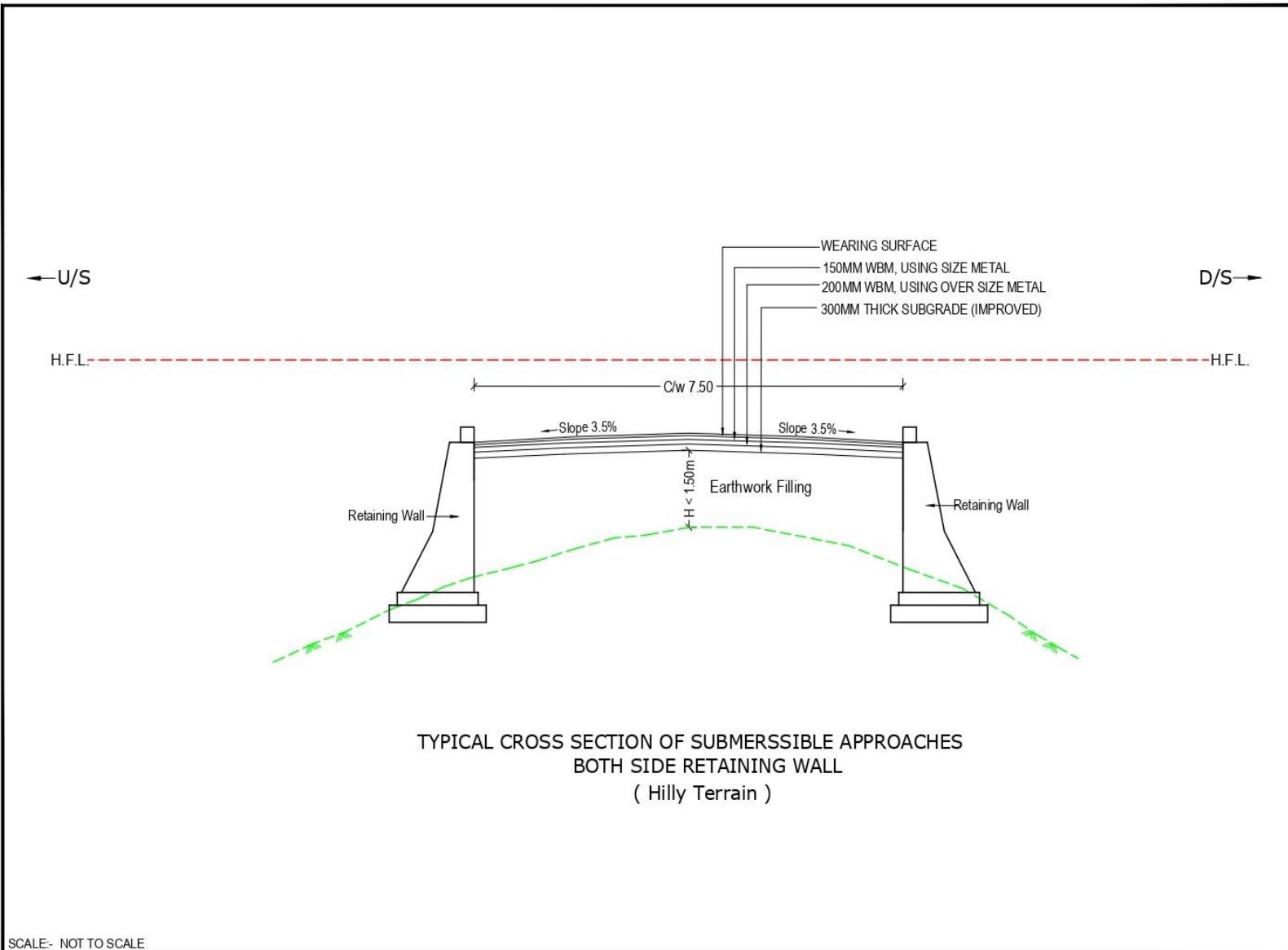


Figure No. 14

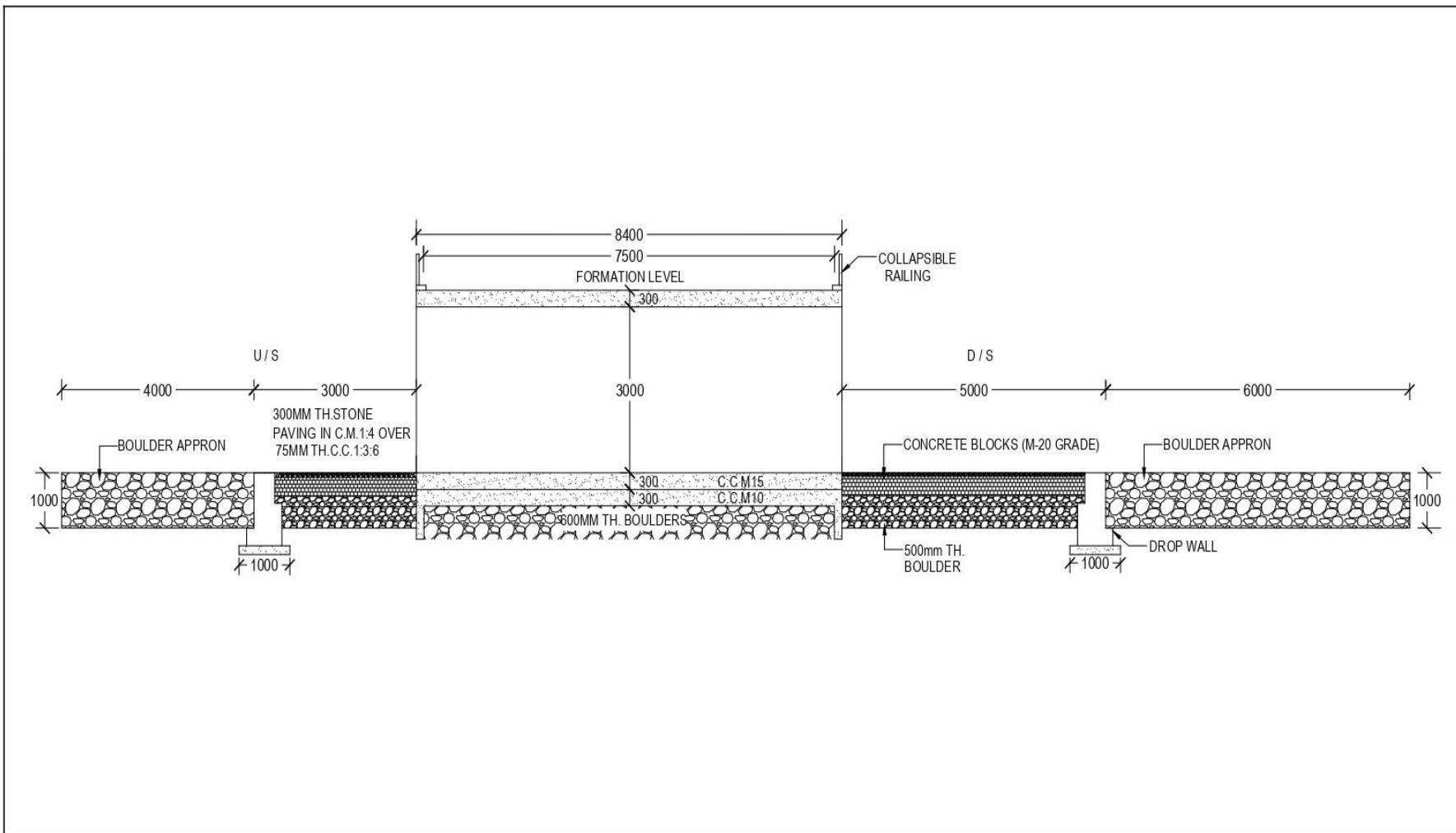
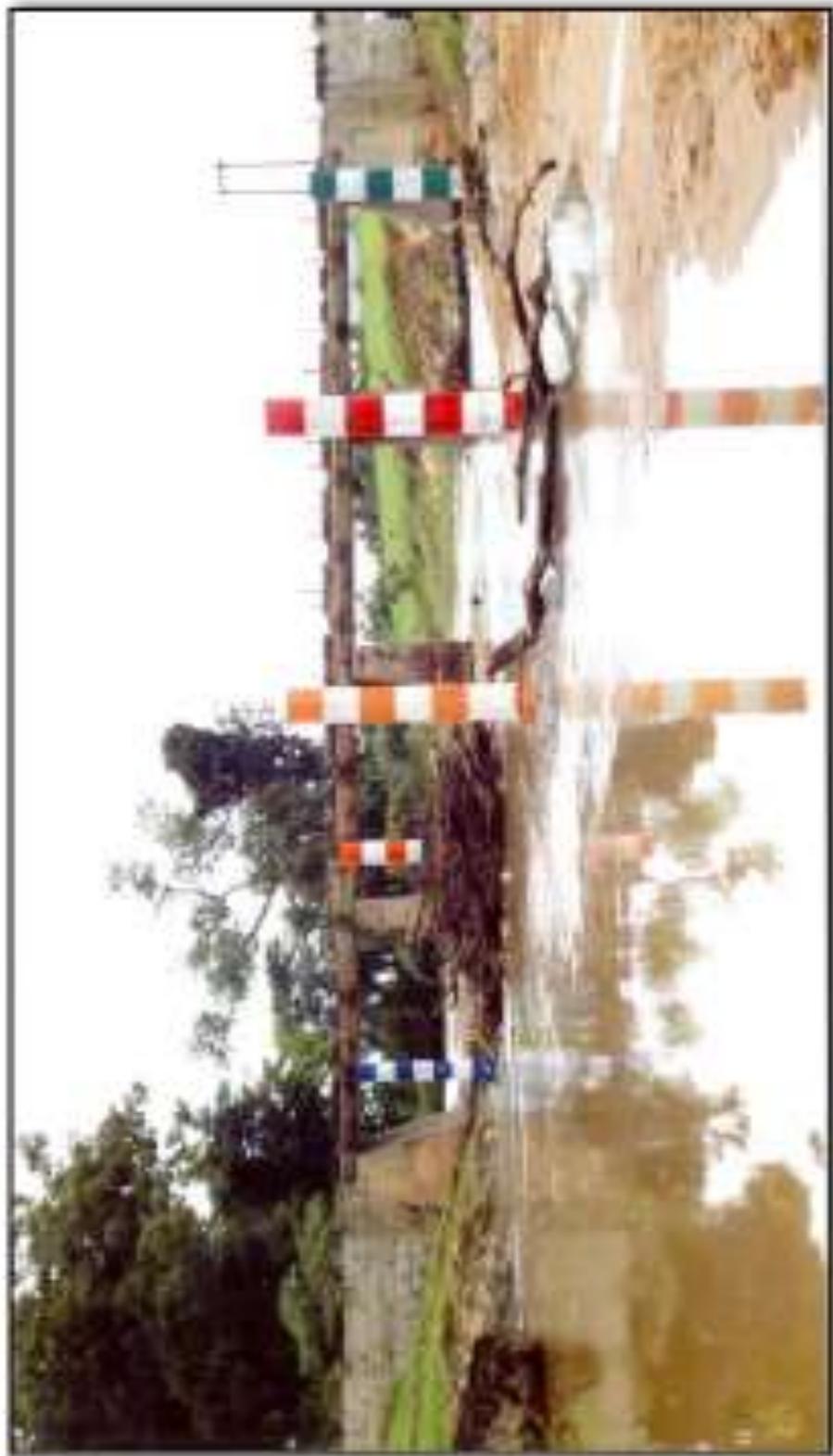


Fig. 5.1. Typical Section Through Bridge Floor

PHOTO-1

The following photographs showing Debris Arrester



Debris Arrester / Reflector in Gadchiroli District

PHOTO-2



Debris Arrester / Reflector in Gadchiroli District

Site Photographs of Damaged Bridge & Approaches

PHOTO-3



Time: 07-16-2022 14:25
Note: Bopapur village Bridge damaged

Damaged Approaches of Bridge on Jalalkheda-Bopapur Road in Narkhed Taluka of Dist. Nagpur

PHOTO-4



Damaged Approaches of Bridge on Jalalkheda-Bobapur Road in Narkhed Taluka of Dist. Nagpur